METHOD TO LINEARLY MEASURE GAS VOLUME FLOW IN DUCTS AND FLOW SENSOR

FIELD OF INVENTION

The invention comprises the development of a method to obtain a linear ratio between the differential pressure and the volumetric flow of a gas in conducts, and a sensor to measure the gas flow for medical applications using such method.

BACKGROUND

There are several ways to measure the volumetric flow, for example, using differential pressure, thermal elements, magnetic elements, among others. The sensors used to measure volumetric flow by means of differential pressure include the Verituri Tube, plate-orifice and variable-area obstruction.

The current variable-obstruction-operating sensors are characterized by using a perpendicularly aligned flexible plate to the direction of the gas flow; when flow is increased, the plate bends generating an increase of the flow path area. This plate has a complex form in order to obtain the linearization between the variation of the differential pressure and the variation of flow.

Patents US4989456, US5038621, US5033312, EP0373886, EP331772, EP331773, US4083245 and US4197857 reveal variable-area-obstruction flow sensors; due to the complex form of their plates, the variation of the differential pressure with regard to the variation of the volumetric flow is linear.

OBJECTIVES

To develop a method to linearly measure volume flow in ducts.

To develop a sensor to measure gas volume flow with the following characteristics:

- Linear ratio between the variation of the differential pressure and the variation of the respiratory volumetric flow.
- Low resistance to flow.
- Measurement of the volumetric flow in both directions.

BRIEF DESCRIPTION OF THE INVENTION

A method has been developed to obtain a linear ratio between the differential pressure and the volumetric flow of a gas, and a sensor to measure gas flow for medical applications using such method.

The method allows to obtain a linear ratio between the differential pressure and the gas flow, using a rectangular-section elbow and a rectangular flexible plate, that is, when the flow passes through the duct, linearization is obtained by combining duct resistance and variable-area obstruction caused by the plate.

The sensor uses this method to linearize the ratio between the differential pressure and the volumetric flow. It has a symmetric structure with regard to its cross section and therefore measures the flow in both directions.

The design of the sensor includes the elbow described in the method, two elbows joined to the sensor by their ends, a flexible plate and two spigots. These three elbows are consecutive and have a rectangular section, and redirect the flow in three stages; the two elbows jointly have a tubular segment at their ends for connection with other accessories. The rectangular-shaped flexible plate is located within the sensor, and matches the symmetry cross section at rest. The spigots through which the differential pressure signals will be obtained are parallel to each other and are located at the outer elbows, on the same side of the fixed edge of the plate.

This sensor is especially developed for Pulmonary Ventilators. Given that it measures the flow in both directions, it is used to measure the inspiration and expiration flow.

DRAWING DESCRIPTION

Figure 1 shows the diagram of the method.

Figure 2 shows the sensor design.

Figure 3 shows a cross section of the flow sensor, where the flexible plate may be seen in its rest and working states.

Figure 4 shows the flexible plate at rest.

Figure 5 shows a cross section of one of the spigots.

Figure 6 shows a cross section of one of the tubular segments.

DETAILED DESCRIPTION OF THE INVENTION

A.- Variable Obstruction Method.

The various applications require to linearly measure the gas flow to predict its behavior and expand the flow measurement range in ducts.

The method developed consists in using a rectangular section elbow and a rectangular flexible plate located inside the elbow (Fig. 1), in order to linearize the ratio between the differential pressure and the flow of a gas.

The variable obstruction method uses the differential pressure to measure the gas volume flow; plate flexibility, duct shape and variation of the flow generate the pressure drop. At low flows, the loss of energy caused by the plate has a greater influence on the differential pressure than the one caused by the duct (slight bending of the plate); whereas, at high flows, the loss of energy generated by the duct shape has a greater influence on the differential pressure (the bending of the plate increases with regard to the bending at low flows).

B.- Gas flow measurement sensor

The development of the sensor to measure gas volume flow comprises the use of three elbows, a flexible plate and two spigots, and to obtain such linear ratio the previous method is used. (The explanation will be made by using Figures 3 to 6).

The sensor has a symmetric structure with respect to the cross section A-A (Fig. 3). It is formed by three elbows (5, 6 and 7, Fig. 3). The elbows at the ends (6 and 7) have a 45° angle and a tubular segment at their ends (10,11), for connection with other accessories, the inflow (10) and outflow (11) segments are aligned to each other, and the intermediate elbow (5) is at a 90° angle. These elbows are used to redirect the flow in three stages.

This sensor has two spigots (8 and 9) which are parallel to each other, and are located at elbows 6 and 7. They are located on the same side of the rectangular section of the duct or insertion edge (curb) of the plate, and are used to connect a differential pressure transducer therein. The total sensor segment comprised between such spigots has a rectangular section.

The plate used is made of polymer, is flexible and 0.1mm thick. It is rectangular-shaped and fixed at the distal curb of the intermediate elbow. Figure 3 shows the plate at two stages, rest state 2 is shown while there is no flow circulating through the duct. At this stage, the plate matches the symmetry cross section of the sensor. Stage 3 occurs when gas flow is circulating.

The rectangular shape and thickness of the plate (depends on the flow range intended to be measured) significantly reduces the vibration of the plate caused by the passing of the flow. The vibration of the flexible plates used in conventional sensors are not desirable because this phenomenon reduces the accuracy and reliability of measurements. In lab conditions, the range of displacement of the vibration of the plate-free edge was below 0.5 mm when the sensor was at the upper limit of the measurement range (maximum flow). Furthermore, the shape and thickness of the plate prevents the breaking of the polymer microscopic chains. This breaking phenomenon causes the plate to lose rigidity with the passing of time, and therefore, measurement repetition.